NEAR DRY MACHINING

IAB Presentation

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OUTLINE

- INTRODUCTION AND MOTIVATION
- PROPOSED RESEARCH PLAN
- EXPERIMENTAL SETUP
- CURRENT RESULTS
- CONCLUSION

INTRODUCTION

Dry Machining

- Health
- Environment
- Cost

Traditional Flood Cooling

- *Cooling*
- *Lubricating*
- *Chip flushing*
- *(Longer tool life)*

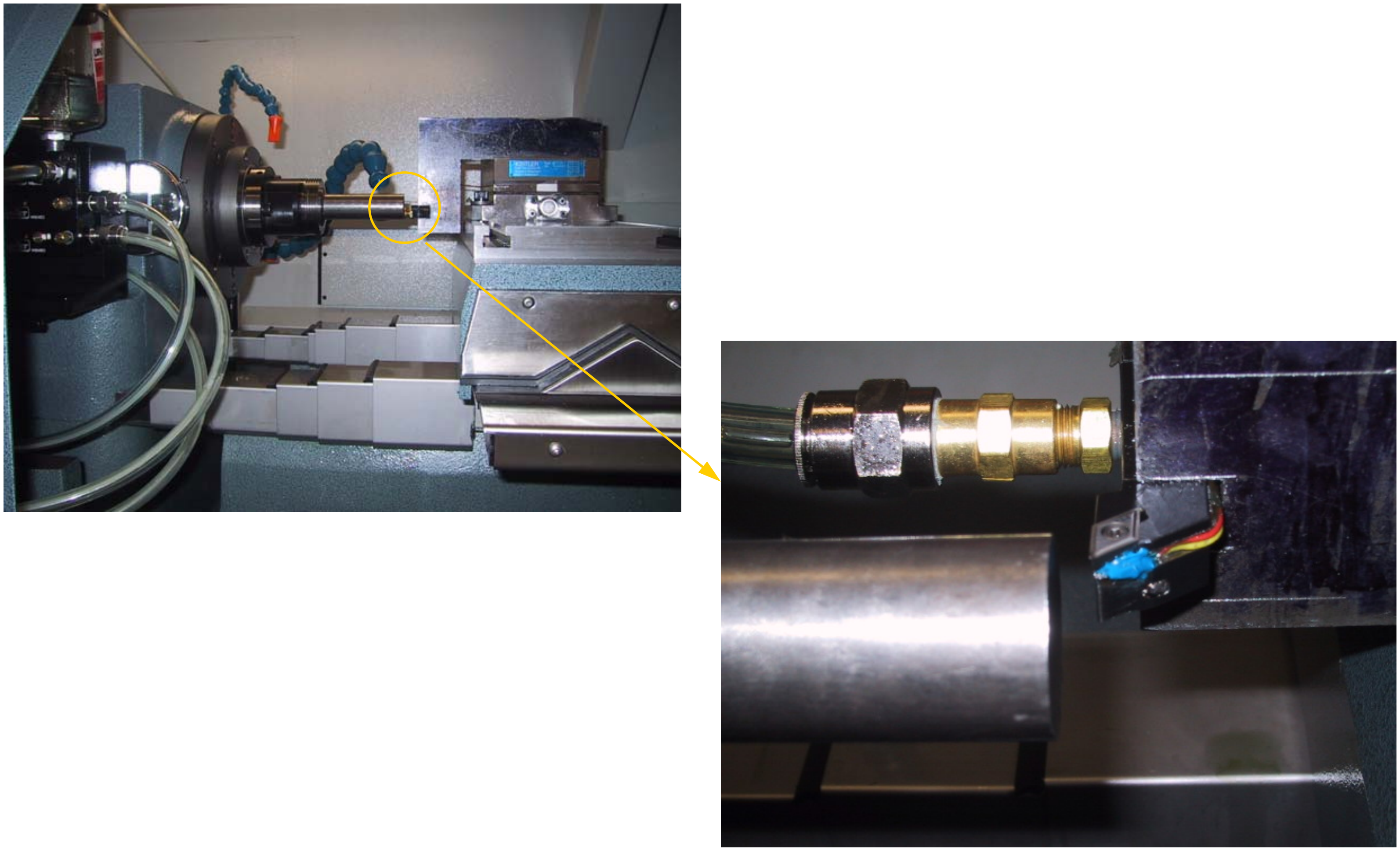
Near Dry Machining

- To extend tool life
- (To improve air quality)
- Small amount of cutting fluid
- Supplied with compressed air

INTRODUCTION (Cont'd)

- Dry Machining vs. Traditional Flood Cooling in Machining
- Benefits of Cutting Fluids
  - Cooling
  - Lubricating
  - Chip flushing
- Disadvantages of Cutting Fluids
  - Health
  - Environment
  - Cost
    - 20% of total manufacturing cost due to cutting fluids vs. 7.5% of total manufacturing cost due to cutting tools
- Near Dry Machining
  - A small amount of cutting fluid, typically lower than 50 ml/hr
  - Only empirical observations

INTRODUCTION (Cont'd)



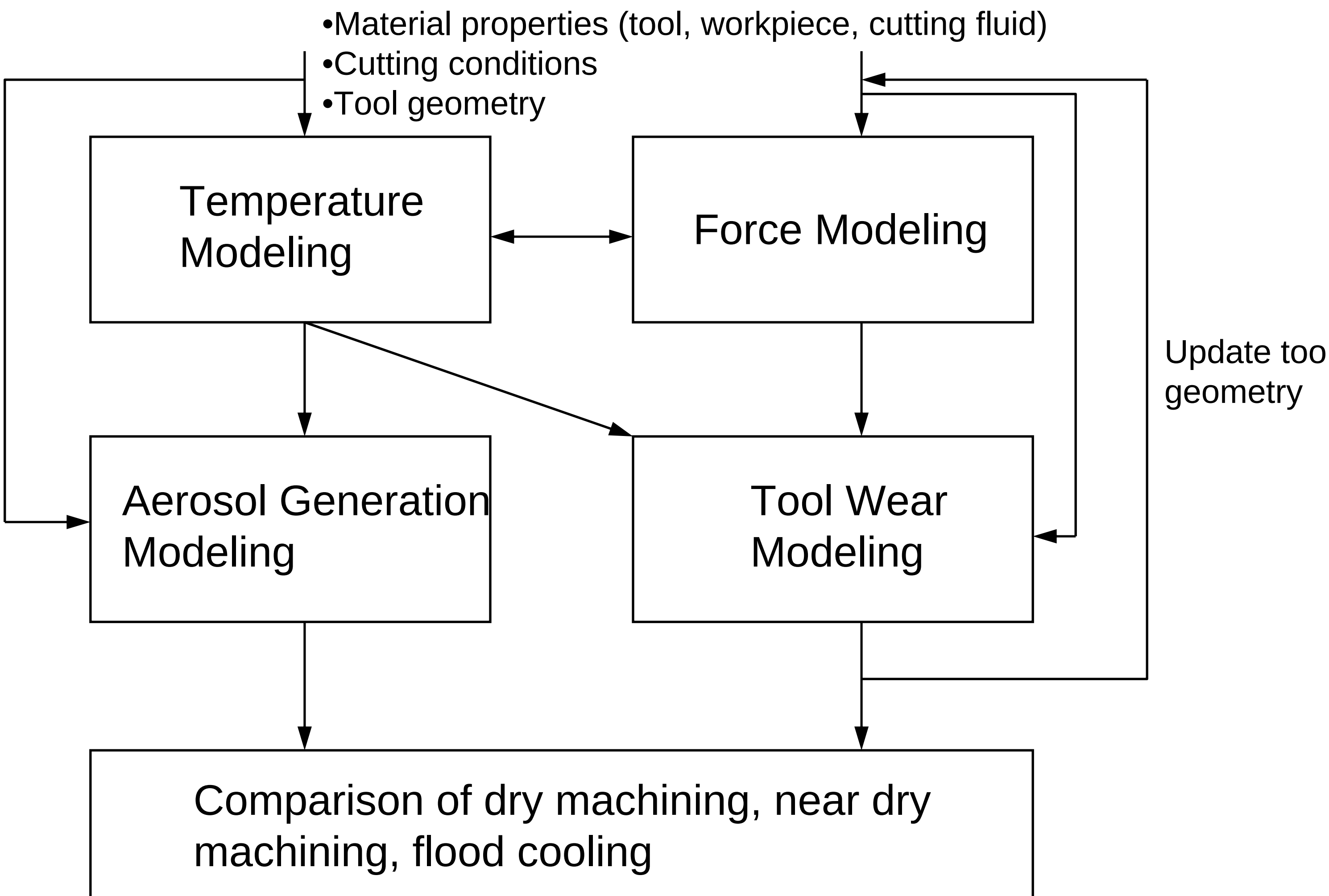
MOTIVATION

- Experimental observations
  - Milling [Rahman *et al*., 2001; Rahman *et al*., 2002; Sasahara *et al*., 2003]
  - Drilling [Braga *et al*., 2002; Brinksmeier *et al*., 2002]
  - Turning [Machado *et al*., 1997; Varadarajan *et al*., 2002; Wakabayashi *et al*., 2003]
  - Not sufficient to identify the “proper” use of cutting fluid
  - Valid only under certain cutting conditions
  - Cannot be extended to different material or cutting conditions based on the experimental results
- The objective of the proposed research aims to develop a systematic and scientific methodology
  - Air quality control
  - Tool life prediction

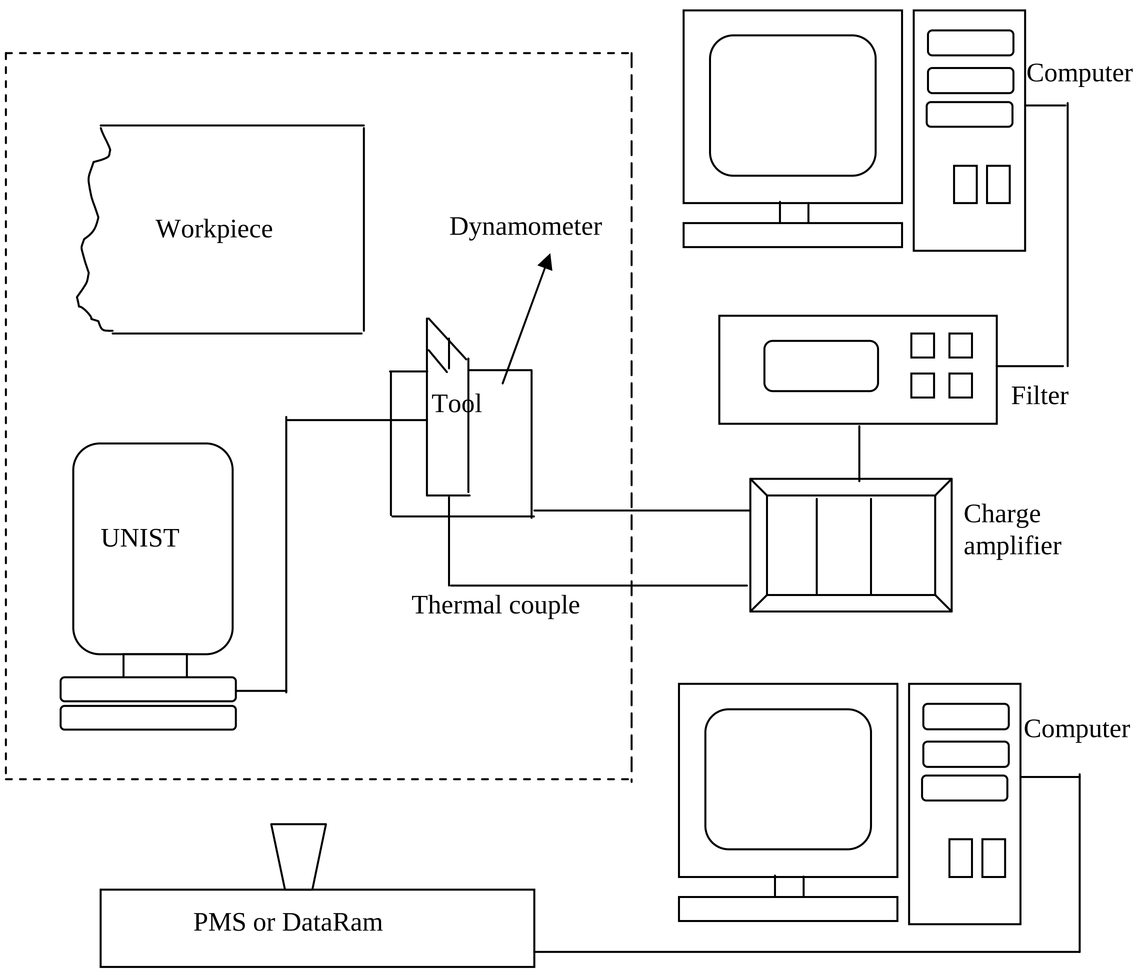
SUMMERY OF PREVIOUS RESEARCHES

- Three mechanisms of cutting fluid aerosol generation: spin-off, splash and evaporation
- Aerosol generation mainly results from the spin-off and splash mechanism in flood cooling.
- Tool performance under near dry lubrication
  - Lower cutting forces
  - Lower cutting temperature
  - Longer tool life
  - Better surface roughness
  - Similar tool performance, compared with flood cooling condition
- Only experimental results in tool performance

PROPOSED RESEARCH PLAN



EXPERIMENTAL SETUP



EXPERIMENTAL SETUP (Cont'd)

MATERIAL AND CUTTING CONDITIONS

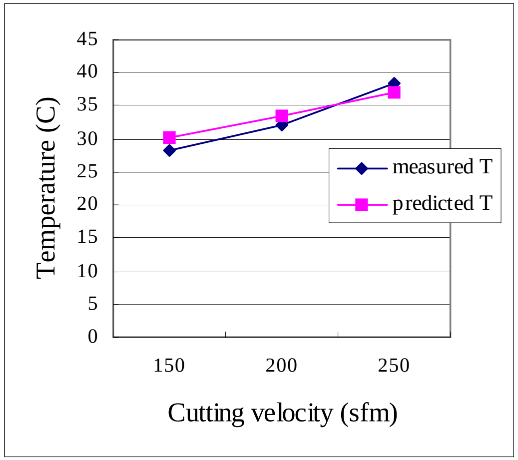
- Turning on a lathe (CMS GT-27)
- Work material: medium carbon steel (AISI 1045)
- Tool material: Valenite VC29 (uncoated carbide)
- Lubricant: UNIST Coolube 2210 (canola oil)
- Cutting conditions:

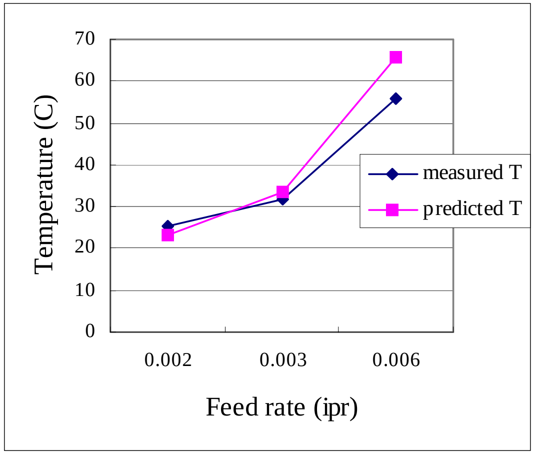
No.	V (ft/min)	f (in/rev)	doc (in)
1	150	0.002	0.02
2	150	0.003	0.04
3	150	0.004	0.03
4	300	0.002	0.04
5	300	0.003	0.03
6	300	0.004	0.02
7	450	0.002	0.03
8	450	0.003	0.02
9	450	0.004	0.04

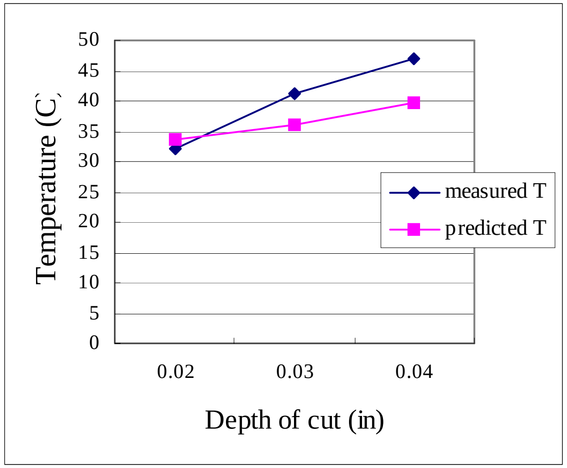
CURRENT RESULTS (1)

❖ Temperature prediction

– Temperature at thermal couple location

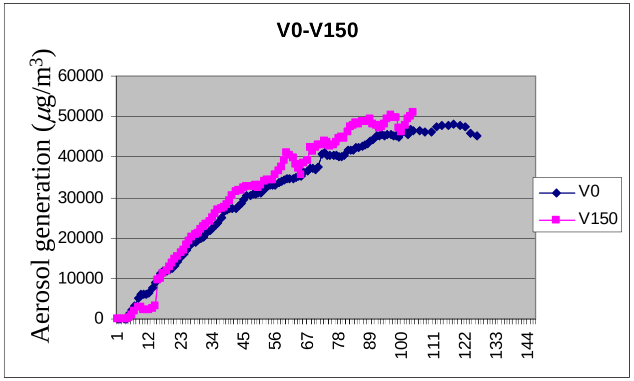


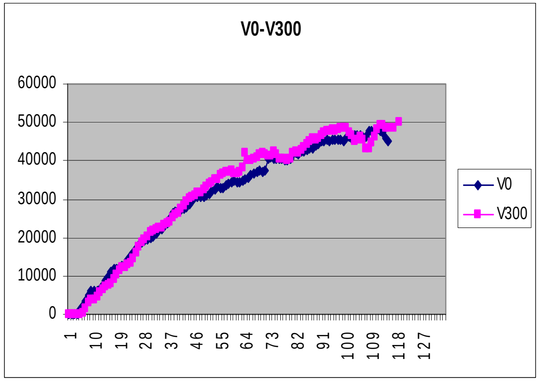


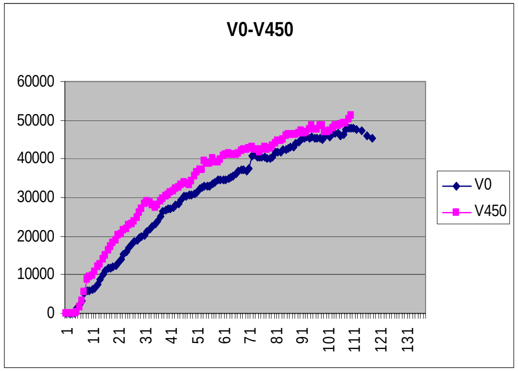


CURRENT RESULTS (2)

- Three mechanisms of cutting fluid aerosol generation: spin-off, splash and evaporation
- Spin-off
  - Due to centrifugal force on the workpiece in rotational motion
  - Insignificant in near dry machining
    - The quantity of lubricant is small
    - Not sufficient to form an oil film on the workpiece

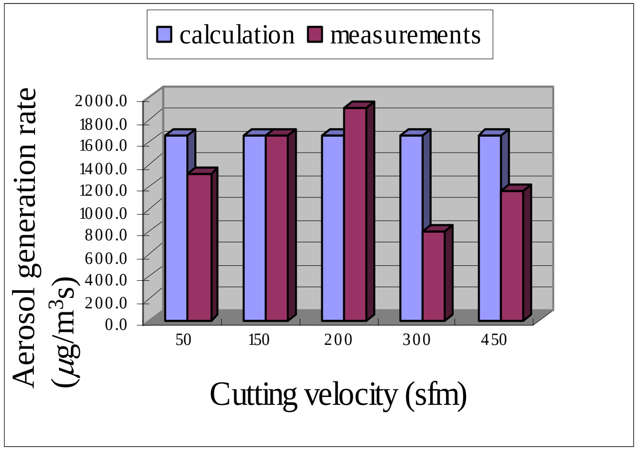


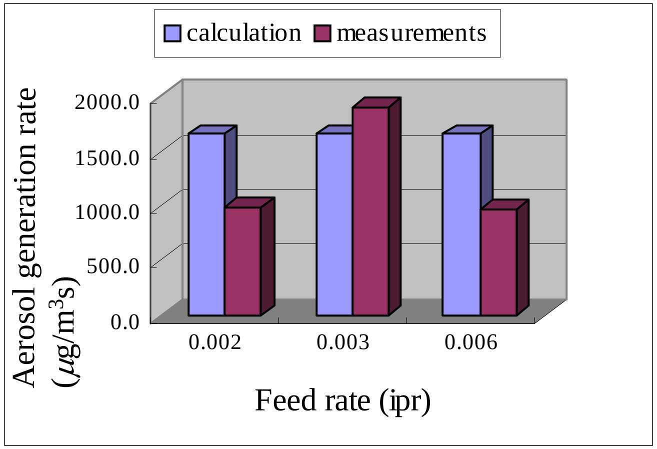


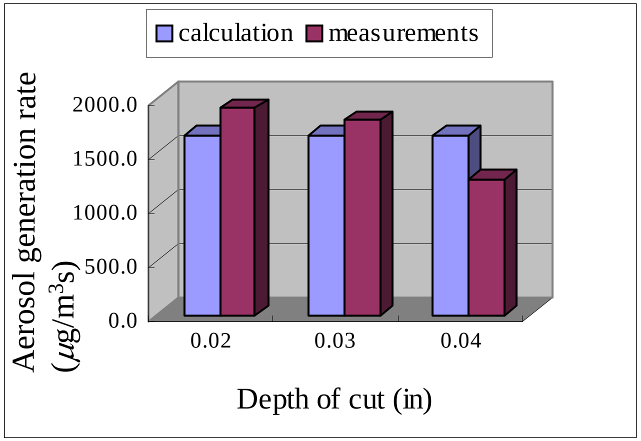


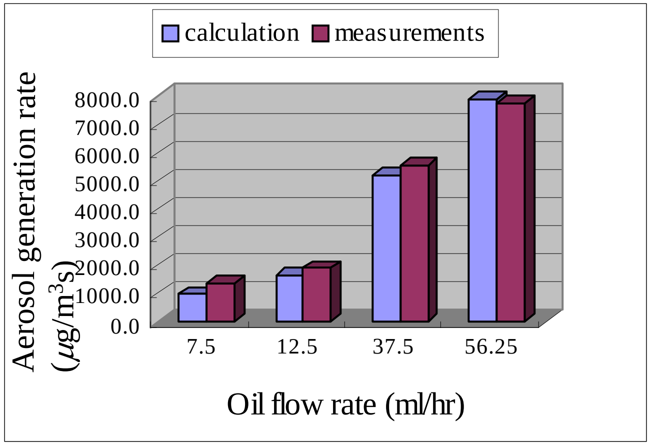
CURRENT RESULTS (3)

- Aerosol generation rate in near dry turning



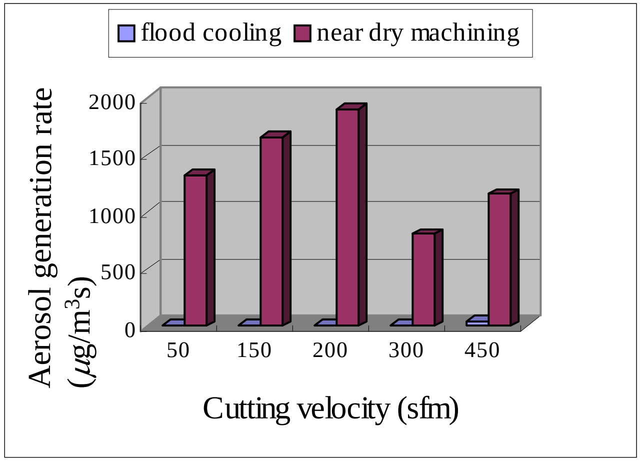


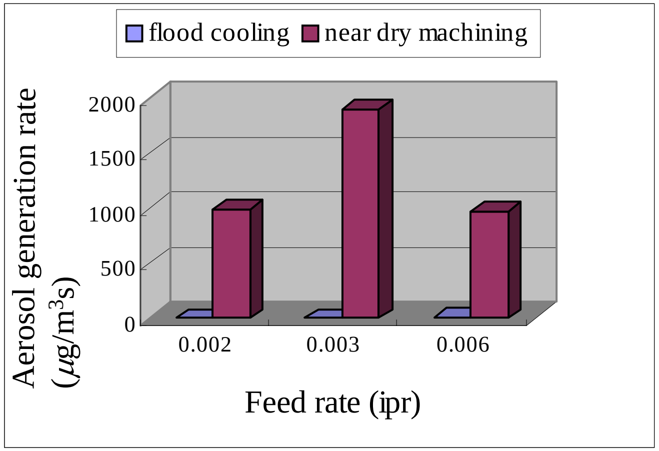


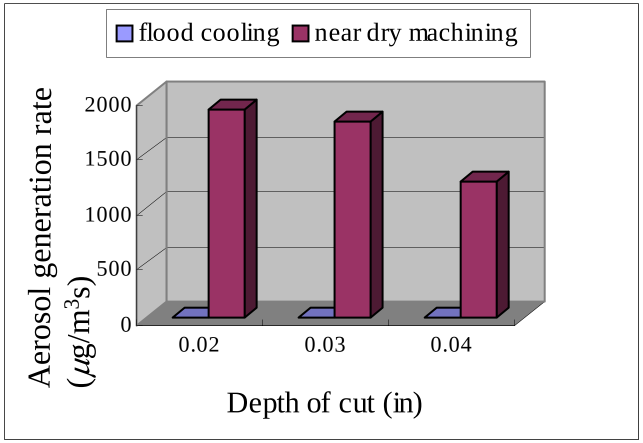


CURRENT RESULTS (4)

- Experiment results for near dry turning and flood cooling
  - Near dry turning: ~1000 μg/m³/s
  - Flood cooling: ~10 μg/m³/s

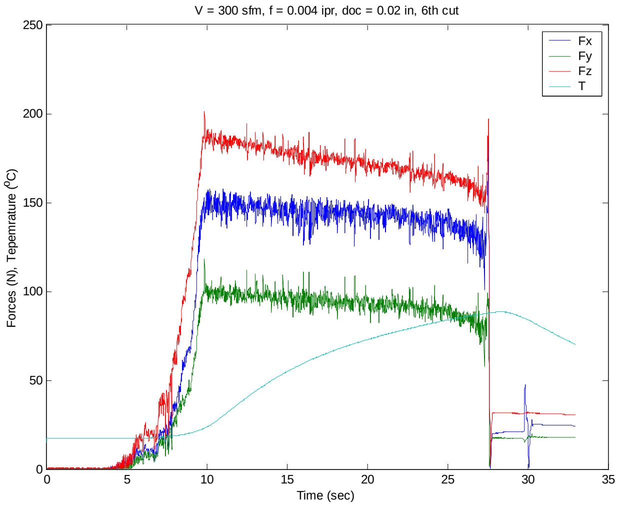






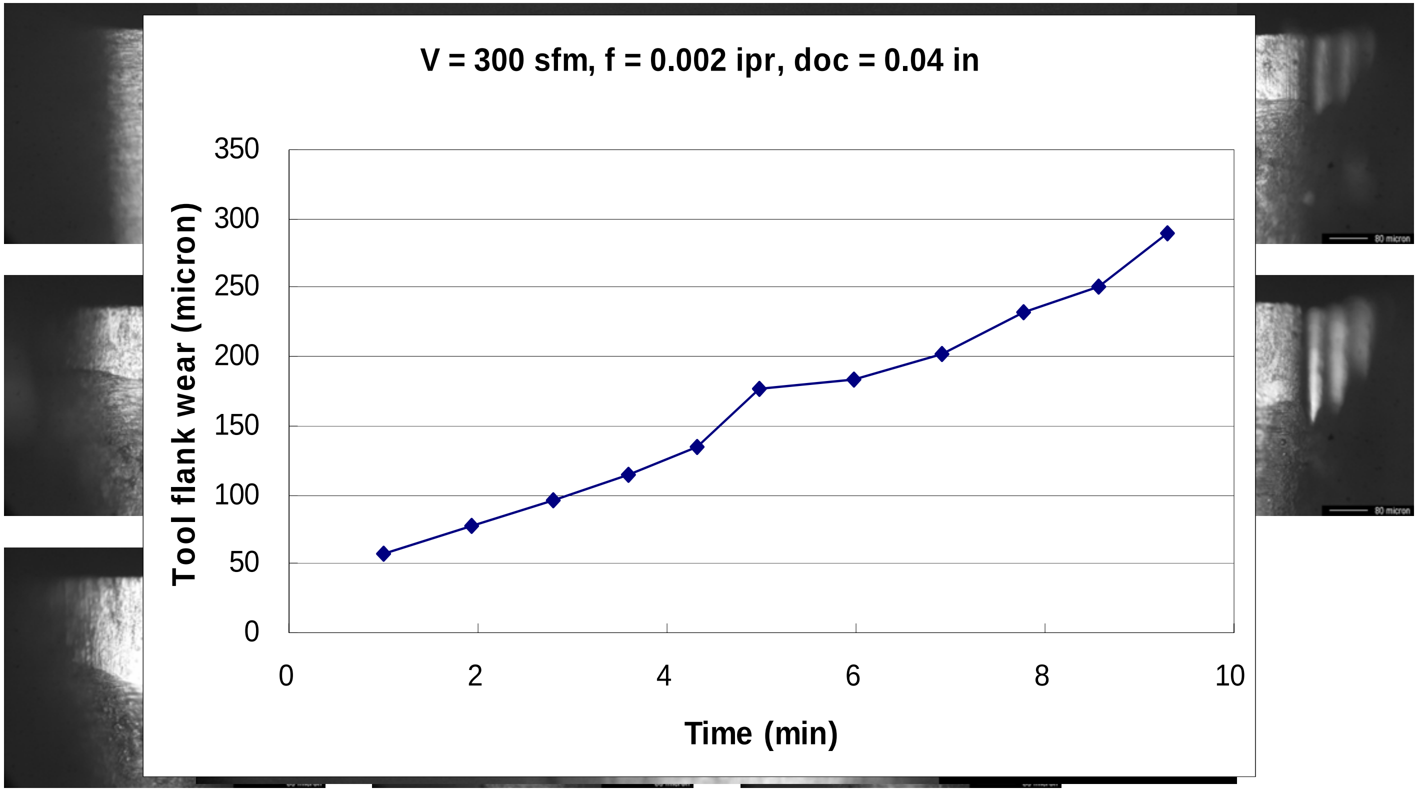
CURRENT RESULTS (5)

- Tool wear test
  - Cutting forces
  - Cutting temperatures
  - Flank wear length
- Cutting forces and cutting temperature measurements
  - example: dry machining



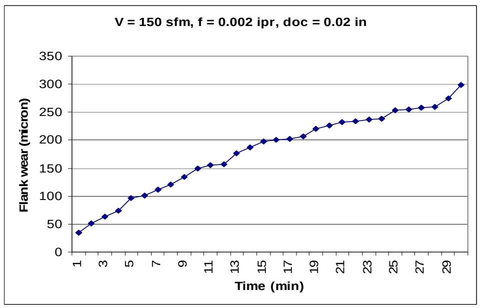
CURRENT RESULTS (6)

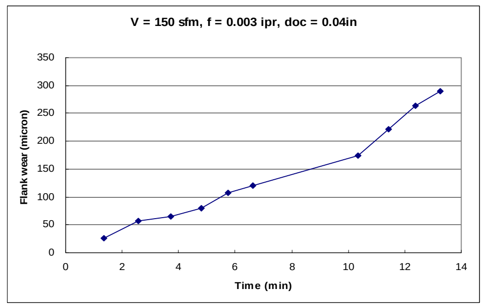
❖ Example of tool wear measurement (dry machining)

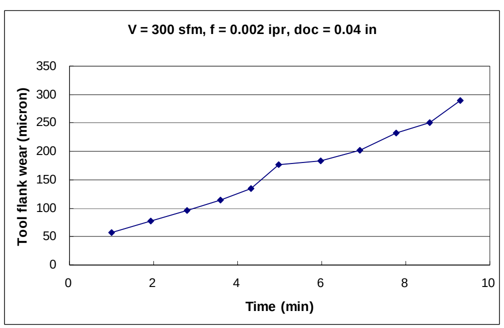


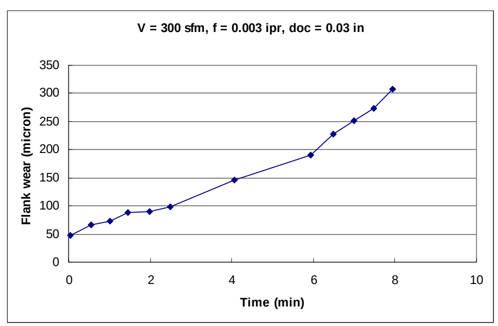
CURRENT RESULTS (7)

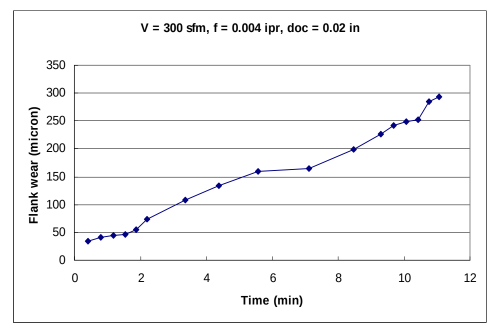
❖ Tool wear rate: $\frac{d\overline{VB}}{dt}=\frac{(\cot\gamma+\tan\alpha)}{\left[\overline{VB}(R-\overline{VB}\tan\gamma)\right]}\left\{K_{abration}K(\frac{P_a^{n-1}}{P_t^n})V_c\overline{VB}\,\overline{\sigma}+K_{adhesion}e^{aT}V_c\overline{\sigma}+K_{diff}\sqrt{V_c\overline{VB}}^{\,\frac{K_Q}{T+273}}\right\}$











CONCLUSION AND FUTURE WORK

- Cutting temperature results shows a good agreement with the analysis model
- Only cutting fluid flow rate affect the aerosol generation rate in near dry turning
- Aerosol generation rate in near dry turning is much higher than that in conventional flood cooling
- Force model establishment and validation
- Tool wear model establishment and validation
- Optimization for air quality and tool life